tions on the detector. By means of two such stations some miles apart the distance of the vessel could also be approximately determined.

In conclusion, Prof. Fleming pointed out that although much work had been done, large districts of research were still incompletely explored. The variable transparency of the atmosphere to these waves was, for instance, not yet fully explained. Very long transmissions were dependent, not only on special skill in devising the apparatus used, but also on the condition of the atmosphere. Sunlight, for instance, had been found prejudicial to the transmission of these waves. It was now known that there were numerous positive and negative ions in the atmosphere. These, when a wave passed, were moved by it, absorbing energy, so that an atmosphere charged with ions corresponded to a slightly turbid medium.—Engineering.

# THE TELESCOPE.*

## ITS GENESIS AND ITS ACHIEVEMENTS.

BY D. B. MARSH.

THE telescope is undoubtedly the most important of all astronomical instruments. It has given almost a new sense to the human race, whereby many of Nature's greatest mysteries have been revealed, and it is the instrument to which is attached the numerous recent devices, such as the camera and the spectroscope, which have so greatly aided in the study of celestial physics.

The exact date of the invention of the telescope and the inventor's name are not known. It was probably used in Northern Europe prior to 1609. In a casual way, Galileo learned of an instrument constructed with a large double-convex lens in combination with a smaller double-concave lens, placed in a lead tube, and so arranged that far-away objects were distinctly observed.

Though Galileo was unable to see one, he soon wrought out the principle and constructed a telescope which magnified three times. This was shortly superseded by one magnifying eight times and so encouraged was he by this instrument that he soon constructed one magnifying thirty times. This was a great success, and many discoveries were made by it—lunar mountains were seen for the first time, spots on the sun were observed, the planet Venus was shown to have phases similar to our moon; Jupiter was found to have moons, and Saturn to have strange appendages, and the Milky Way was shown to be composed of myriads of stars.

The Galilean telescope was a wonderful instrument in its day, but it was soon to be surpassed. In 1637 Kepler suggested a telescope with two convex lenses in combination. The larger lens, as in Galileo's telescope, was placed toward the object to be viewed, but the smaller lens, instead of being concave on both sides and placed inside the focus of the large lens, was a double-convex lens and was placed beyond the focus of the objective or large lens. This smaller lens was held near the eye, and was called the eye-piece.

After considerable experimenting, it was found that a comparatively small objective, with a long focus, was the most satisfactory. In 1672, Campani, of Bologna, constructed an instrument of this kind 136 feet long. Huygens made one 123 feet long, which he presented to the Royal Society of London, while Auzout had one constructed 600 feet in length, but it was too unwieldy. These telescopes, notwithstanding their great length, were far from perfect, as they were affected by both chromatic and spherical aberration. Newton believed it impossible to correct the chromatic defect, and in deference to the great philosopher's judgment, no one for some time seriously attempted the task. However, in 1758, an English optician named Dollond proved Newton wrong. On carefully examining various kinds of glass he observed that some specimens had greater dispersive power, and it occurred to him to make a telescope objective combining two different kinds of glass. He found that by combining a convex lens of crown glass, which has the least dispersive power, with a concave lens of flint glass an image could be formed with almost no chromatic defect.

This was another great step in the construction of telescopes, for with a 3-inch objective and a focus of only 45 inches, a magnifying power of 200 could be had. It is interesting to note that, owing to the difficulty of procuring optical glass, Dollond never constructed a telescope larger than 4 inches in diameter.

Between 1830 and 1860 the manufacture of optical glass was much improved, and lenses were made as large as 12 and 14 inches in diameter. In 1861, one 18 inches in diameter was made for the Dearborn Observatory at Evanston, Illinois. In 1871, this was surpassed by one of 26 inches aperture made for the U. S. Naval Observatory at Washington, D. C. These splendid objectives were made by Alvan Clark, of Cambridgeport, Mass., whose firm indeed has constructed some of the largest in the world—that of the Lick telescope, 36 inches in diameter, and the Yerkes, 40 inches in diameter. The lens of the Lick telescope, in its cell, weighs about 700 pounds and cost $53,000. The focal length is 56 feet. The Yerkes objective weighs half a ton and cost $65,000.

So far I have been speaking of refracting telescopes only. Let me ask your attention briefly to reflecting telescopes. These are of three kinds—the Gregorian, the Cassegrainian, and the Newtonian. Philosophers believing it impossible to overcome the unequal refrangibility of the different colored rays of light, gave up the idea of perfecting the refracting telescope, and directed their attention to constructing an instrument on a different principle, using a concave mirror to form the image of the object observed. Mersenne, in 1639, suggested the employment of a spherical mirror, but the idea appears to have been dropped. Quite independently Gregory, in 1663, proposed a similar arrangement, using however a parabolic in place of a spherical mirror. He endeavored to find a workman able to construct such, but could not at that time.

In the Gregorian instruments the parabolic reflector is placed at the lower end of the tube, while on its axis and a short distance beyond its focus, is placed a small concave reflector. The light from the distant object falls upon the large mirror, from which it is reflected back to the small one, which throws it back through a hole in the center of the large reflector. It then passes into the eyepiece, which indeed in Gregory's time had been much improved by Huygens.

Gregory's efforts along this line turned Newton's attention to reflecting telescopes, and he set to work experimenting on an alloy suitable for a speculum. In 1669, he cast his first disk and began to grind it, but it was not until 1672 that he had real success. Then he made two small instruments, one of which was only about an inch in diameter, with a magnifying power of about 38.

The principle of Newton's telescope differed from Gregory's in that it had a small plane mirror placed in the cone of light from the reflector, at an angle of 45 degrees. Being placed inside the focus, this mirror turned the light cone at right angles to its original direction, thus forming the image outside the tube, and obviating the necessity of a hole in the parabolic reflector.

About the same time that Newton completed his instrument, the Cassegrain construction was proposed. This was the same as the Gregorian telescope except for the small mirror. In the Gregorian this mirror was concave, while Cassegrain proposed a convex mirror, to be placed inside the focus. It brings the light from the object to a focus through a hole in the center of the large parabolic mirror.

The largest Cassegrainian telescope in use to-day is in the Melbourne Observatory, erected in 1870. It has an aperture of four feet, and is used in observing and photographing the nebulæ and star-clusters in the southern hemisphere.

Owing to the difficulty in obtaining a suitable alloy, little progress was made for some time in constructing reflecting telescopes. In 1718, however, Hadley, the inventor of the sextant, constructed one on the Newtonian principle, 5 feet in length. The instrument magnified over 200 times, and it revealed as much as the old refracting telescopes. Perfect as this Newtonian telescope seemed to be, the Gregorian type held the field until 1774.

By using a small Gregorian telescope, Herschel had his attention directed to the wonders of astronomy, but his income being too limited to purchase an instrument he set about making one for himself. During his life, he is said to have made upward of 400 telescopes, mostly of the Newtonian type. Among his earliest efforts was the construction of a 5-foot reflector which was a grand success. Then came one 7 feet in length. The largest of his instruments was completed under George III. in 1789. This telescope surpassed all previous efforts, as it was actually 40 feet long, and had a reflecting mirror 4 feet in diameter. The story of Herschel's work with this great telescope would fill a volume.

One of the best specimens of the Newtonian reflector was produced by Mr. Lassell, of Liverpool, England. With it two satellites of Uranus, a satellite of Saturn, and the single satellite of Neptune were discovered. This instrument is now in the Royal Observatory of Greenwich.

The largest telescope of the reflecting type was constructed by Lord Rosse, an Irish peer. It has a diameter of 6 feet, but it can be used only for observations on or near the meridian. At the present time both refracting and reflecting telescopes are in use, and are brought to a great degree of perfection. Just which is better, it would be hard to say. It depends largely on the requirements of the observer. The old speculum metal reflector has been almost discarded, and glass, coated with silver, has been substituted. The glass is much superior to the metal, as it can be figured more accurately, and if tarnished the silver can be renewed without changing the figure of the mirror.

For observing nebulæ and star clusters, perhaps the reflecting telescope is to be preferred, provided the mountings are suitable. The silvered mirror can be made to reflect 90 per cent of the light it receives. The refracting telescope is much more convenient to manipulate, and requires much less attention. The lenses are so perfectly made that the chromatic and spherical aberrations are reduced to a minimum, so far as visual observation is concerned. For photographic purposes, an extra lens is sometimes placed before the visual objective, which suitably corrects for the rays effective in photography. This is done on the 36-inch Lick, and the 40-inch Yerkes. In some cases the light passes through colored screens which allow to pass only those rays for which the telescope is corrected. Taylor, of the firm of Cooke & Sons, has devised a "triple" objective, which, it is claimed, is suitable for both visual and photographic work without the use of screens.

Lastly, let me refer to the horizontal telescope. In this case the telescope is rigidly fixed along the ground and the light from the heavenly body is reflected into it by a perfectly plane mirror moved by clockwork.

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## CAUSES OF THE QUALITY STRENGTH IN WHEATEN FLOUR.

By A. E. HUMPHRIES.

SPEAKING before the British Association at Leicester, England, A. E. Humphries said that the Home-grown Wheat Committee of the National Association of British and Irish Millers has for several years been engaged in producing wheats in England which shall yield maximum crops of grain and straw, the wheat to be equal in strength, and therefore in commercial value, to the best imported varieties.

The field of inquiry has been a wide one, and among other things the committee has sought to ascertain "the ultimate cause of strength in wheat, the nature and source of those constituents which confer on some varieties of wheat the inherent quality of strength, and the power of transmitting it to succeeding generations." It has been proved that though climate and soil influence quality they are not the determining factors in the production of strength, for though the strongest wheats are ordinarily produced in districts where the winters are cold, the summers hot, and the summer rainfall high, certain varieties possess and retain the inherent quality of strength when grown in England. Manuring or early cutting at harvest time has no beneficial effect on quality. Quick growth or rapid maturation is not correlated with strength nor does the percentage of natural moisture in well-harvested wheat indicate it; indeed, in certain cases the addition of water to wheat materially increases its effective baking strength.

The term "strength" has been loosely applied to cover several characteristics. It should not be measured by the quantity of water required to make doughs of a standard consistency, nor by the quantity of bread produced per sack of flour used, nor by the way a flour behaves in the dough, but by its capacity for making big, shapely, and therefore well aerated loaves. This definition covers two characteristics; one, a flour's capacity for making gas in yeast fermentation; the other, its capacity when made into dough for retaining the gas so generated.

The gas-making power will depend largely on the percentage of natural sugar any given wheat contains and its diastatic capacity. These characteristics vary substantially in different wheats. The baker can, and does, influence the quantity of gas generated in baking. The retention of gas when made involves complex problems.

The percentages of total nitrogen, gluten, gliadin, and amyloids do not correctly indicate the relative strengths of various flours. The theory that strength depends on a correct ratio between gliadin and gluetenin is untenable. Prof. Wood's suggestion that the gas-retaining power of a dough depends on its ratio of